The loaning of museum material to the schools has continued; lecture courses or lessons have been offered to the children who have come as delegates from their respective school rooms; several illustrated lectures have been given at the schools; instructional courses open to the teachers of nature study have been offered and university credit courses have been conducted for those wishing to systematically pursue courses of instruction.

It is evident from the work, both of the museum and of the instructional courses given in cooperation with the work of the museum, that the academy is rapidly assuming a conspicuous place among the educational institutions of Chicago. The expressions of appreciation which have come to us from the superintendent and district superintendents of the public schools have been most encouraging. The expressions of appreciation which reach us from the principals and teachers more immediately engaged in the educational work of the North Side, are enthusiastic in praise and appreciation of the influence which the academy is having.

The opportunities for the academy lie far beyond anything which we have yet realized. The North Side of Chicago is distinctly lacking in any public institution which is actively assisting in the educational work of the schools and offering instructional courses for adults. The work of the academy should be consistently restricted to the utilization of the scientific data and material in educational work, but the opportunities within that field are among the most attractive that are open to any educational workers.

It is, indeed, somewhat surprising to see how easily the academy may become an effective instrument in the educational work of the city. There seem to have been so many gaps, so many places where we may fit in, and the regret is that we have not better facilities at the building and a larger force who may put their personal efforts into the promotion of science work among the young people and teachers of the city.

The institution has outgrown its present quarters and the demands upon it and the opportunities open to it indicate that the additional building which was originally planned for the institution should now be erected. We need a new building with an auditorium which has a seating capacity of five to eight hundred for various meetings and lectures. Class rooms, laboratories and children's work rooms in which courses of instruction may be conducted, should be provided and a children's museum should be placed in this additional space.

WALLACE W. ATWOOD,
Secretary

SOCIETIES AND ACADEMIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

THE 688th meeting of the society was held on January 28, 1911, President Day in the chair. Three papers were read:

Integers Useful in Computing Square Roots of Numbers: Dr. R. S. WOODWARD, of Carnegie Institution of Washington.

This paper is a continuation and extension in application of the paper on "A Method of Precision for Computing Square Roots of Numbers," presented by the speaker at the 680th meeting of the society. This paper will later appear in full in the publications of the American Mathematical Society.

A Method for Grading the Results of Tests in Judging: Dr. LYMAN J. BRIGGS, of the Department of Agriculture.

This paper describes a rational method of grading student tests in judging such as are now extensively held in agricultural schools. These tests consist in determining how nearly five or more objects can be arranged in the correct order of excellence. Since adjacent objects, when the series is correctly arranged, differ in excellence in varying degree, it becomes necessary to take cognizance of this in grading the arrangements made by different students. Furthermore, since there are seven hundred and twenty possible arrangements of six objects, the grading of the different arrangements becomes hopelessly complicated unless some rational system is adopted.

The system proposed is based upon the three following principles:

1. Any arrangement of objects departing from the correct order is brought about through the exchange of adjacent objects.

2. The error due to transposing two adjacent objects from their correct order is directly proportional to the difference in excellence of the two objects transposed.

3. An erroneous arrangement is penalized in the exact proportion that the error bears to the greatest error that can be made in the series under consideration.

In employing this system of grading the instructor first decides upon the relative difference in excellence between adjacent objects in the

series when arranged in correct order. This virtually amounts to distributing the objects properly along some numerical scale taken as a scale of excellence. Each student's arrangement of the objects is then penalized in proportion to the difference in excellence of the objects exchanged and to the number of exchanges necessary to bring about the correct arrangement. The penalty can be placed upon a percentage basis, if desired, by determining the ratio of any observed errors to that represented by completely inverting the series. The system can be applied to any series either with uniform or non-uniform intervals; it requires no tables, and it can be used with any number of objects.

The Measurement of Two Primary Base Lines with Invar Tapes: Mr. William Bowie, of the Coast and Geodetic Survey.

There are several types of base apparatus which have been used successfully in recent years by the Coast and Geodetic Survey. They are: (1) the secondary apparatus, a monometallic multiple bar system; (2) the duplex apparatus, a bimetallic multiple bar system; (3) steel tapes of 50 and 100 meters in length, and (4) nickel-steel or invar tapes of 50-meter lengths.

The secondary bars and the duplex bars gave very accurate results, yet their operation was more expensive than tapes. Tests made at the Holton base in 1891, by Professor R. S. Woodward, indicated that primary base lines could be successfully measured with steel tapes, and they were used in connection with the duplex bars in 1900 in the measurement of nine bases along the 98th meridian. In 1906 six primary bases were measured with both steel and invar tapes. It was found that the measurement of a base with tapes occupied about twenty days, while the measurement of a base with the bars had usually taken several months.

As the nickel-steel or invar base tapes were satisfactory in the measurement of bases in 1906 it was decided to use them in measuring two primary bases, one at Stanton, Tex., and the other at Deming, N. M., on the Texas-California arc of primary triangulation in 1909–10. These bases were measured by the triangulation party working in the vicinity. Owing to the small coefficient of expansion of the invar metal, it is possible to do the measuring in the hours of daylight. The coefficient of expansion of the tapes used on the primary bases by the Coast and Geodetic Survey is only about one twenty-fifth that of steel.

Four invar tapes, each 50 meters in length, were carried to the field and three of them were used in the measurement. One was held in reserve for use in case of accident to one of the other three. The tapes were standardized at the Bureau of Standards before and after the measurement of each base. The Stanton base has a length of 13,193 meters. The size of the party on this base was two observers and seven other men. One of the observers was Mr. J. S. Hill, the chief of party. During the actual measurements only six persons were engaged.

A very simple tape stretcher was used on the measurements of the Stanton and Deming bases, its weight being only eighteen pounds. The adoption of this simple and light stretcher is a step in the right direction, for the amount of measuring accomplished by a party in any one day depends largely upon the endurance of the man carrying the forward stretcher.

A base 15,554 meters in length was measured in the vicinity of Deming, N. M., in 1910, by the same party that measured the Stanton base in the previous year. The measurement of the Stanton base occupied the party seventeen days, while thirteen days were required for the measurement of the Deming base. The probable error of the measurement of the Stanton base was one part in 2,560,000, and the probable error for the Deming base was one part in 1,960,000.

Some of the conclusions which were drawn from the measurement of these two bases are: (1) the 50-meter tape was found to be both convenient and satisfactory, confirming the conclusions based upon previous tape work by the Coast and Geodetic Survey; (2) invar tapes with measurements made in daylight or at night give results which are as accurate as those obtained by the duplex base bars; (3) it is not necessary to standardize the invar tapes in the field; (4) owing to their small coefficients of expansion invar tapes give more accurate results than steel tapes; (5) with proper care during measurements in the field, the invar tape does not change appreciably in length. While not so elastic as steel, yet it is sufficiently strong to withstand the ordinary shocks due to excessive tension.

It is possible that the invar tape will not find favor with the surveyor and engineer, for general use, on account of its low elasticity, but it has proved to be a most satisfactory apparatus for the measurement of primary base lines by the Coast and Geodetic Survey.

R. L. Faris,
Secretary

THE GEOLOGICAL SOCIETY OF WASHINGTON

THE 237th meeting of the society was held at the Cosmos Club on Wednesday evening, January 11, 1911.

Regular Program

Desert Pavements and Analogous Phenomena: E. E. FREE.

Where wind scour acts on unconsolidated desert materials pebble pavements are of common occurrence. Such occurrences have been described by Blake,[1] Tolman[2] and others. As a result of similar wind scour the surface sand of stable dune areas is often coarser than that underneath. Analogous pavements are occasionally produced by water action.

Nonnezoshe—the great Natural Bridge of Southern Utah: JOSEPH E. POGUE.

Southeastern Utah boasts four natural bridges, the Owochomo, the Kachina, the Sipapu and Barohoini (Piute for rainbow) or Nonnezoshie (Navaho for stone arch), each of which surpasses in size the well-known Virginia natural bridge. The first three of these have been called by commonplace personal names, but the above names are original Indian ones and are far preferable. The largest and most southerly of the four, the Rainbow Bridge, was visited on July 26, 1910, by a U. S. Geological Survey party consisting of H. E. Gregory, in charge, John Wetherell, K. C. Heald and the writer. This imposing structure is situated in San Juan County, in a wild and well-nigh inaccessible part of the Navaho Reservation, just four miles north of Navaho Mountain and near the junction of the San Juan and Colorado rivers.

The La Plata (Jurassic?) sandstone, here 1,200 feet or more in thickness, is deeply dissected by a labyrinth of tortuous canyons, and near the mouth of one of these the bridge is found. A towering arch, rainbow-shaped and of model symmetry, rises from a ledge on one side of the canyon, and spanning a small stream, joins the opposite wall on its downward bend. The opening measures 267 feet in height by 278 feet between abutments; but the distance from stream bottom to top of arch totals 309 feet, while the keystone portion is only 42 feet thick by 33 feet wide. The arch is carved from a buff-colored massive phase of the La Plata sandstone, and represents an opening, enlarged and shaped by desert weathering, through which the stream originally cut off one of its meanders. The abandoned meander remains as a proof of this origin.

The bridge was discovered on August 14, 1909, by W. B. Douglas, of the U. S. General Land Office, with four assistants, and Byron Cummings, of the University of Utah, with three students, under the guidance of John Wetherell and two Navaho Indians. It has subsequently been set aside as a national monument and represents the largest and most graceful structure of its kind thus far known.

Criteria for an Unconformity in the so-called Laramie of the Raton Mesa Coal Fields of New Mexico and Colorado: W. T. LEE.

During the summer of 1910 the unconformity in the coal-bearing rocks of the Raton coal field of New Mexico, first announced in 1908 and published upon the following year, was traced around the Raton coal field in New Mexico and the Trinidad coal field in Colorado, an area extending about ninety miles along the east front of the Rocky Mountains and stretching eastward to a maximum width of fifty miles. The evidences of unconformity may be grouped under two general headings, stratigraphic and paleontologic.

The formation below the unconformity is coal-bearing and varies in thickness from about 450 feet to 0. The formation above the unconformity is likewise coal-bearing and is marked by a constant basal zone of conglomeratic sandstone. The relation of the basal conglomerate of the upper formation to the beds below leaves little room for doubt that the variation in thickness of the lower formation is due to erosion. In at least four places the lower coal-bearing formation is wanting and the basal conglomerate of the upper one rests upon older rocks. This basal conglomerate contains pebbles of coal which must have come from the lower coal formation, pebbles of conglomerate which could come only from the Dakota, stratigraphically about 3,500 feet below, or from some formation still older; pebbles of red sandstone which could come only from the red beds, the top of which is about 4,000 feet below; pebbles of horn corals and fossiliferous cherts, such as are now found in the Carboniferous rocks west of the coal fields, about 18,000 feet below; and a variety of metamorphic and igneous rocks, including crystals of feldspar supposed to come from the crystalline complex of the mountains. Apparently these pebbles prove that after the earlier coal measures were formed the mountains west of the Raton Mesa region were elevated and the upturned stratified rocks, having a measured

[1] Rept. Pac. Ry. Surv., 5: 230, 1856.

[2] *Jour. Geol.*, 17: 149–151, 1909.

thickness of more than 18,000 feet, were eroded before the basal conglomerate of the upper coal measures was laid down.

The paleontologic evidence is almost wholly from the fossil plants, which apparently indicate a time break of considerable duration. Large collections were made from both formations and F. H. Knowlton, who is studying them, states that tney contain two distinct floras. However, correlations are withheld pending the final study of these fossils.

The data collected apparently prove that after the lower part of the coal-bearing rocks in the Raton Mesa region, heretofore referred to the Laramie, had been consolidated the mountains to the west were uplifted and part of these rocks, together with all of such younger beds as may have been deposited, were eroded away before deposition of sediments was resumed in this region. The general conclusion is reached that the so-called Laramie of the Raton Mesa is divisible into two distinct formations separated in time by a period of considerable duration.

Robert Anderson,
Secretary

THE TORREY BOTANICAL CLUB

The meeting of December 13, 1910, was called to order at the American Museum of Natural History at 8:30 P.M., Tuesday, December 13, 1910, with President Rusby in the chair. One hundred people were present.

The scientific program consisted of an illustrated lecture by Dr. Marshall A. Howe on "A Visit to the Panama Canal Zone."

The visit described by the speaker occurred in December, 1909, and January, 1910, and was undertaken under the auspices of the New York Botanical Garden, with the special object of studying and comparing the marine floras of the Atlantic and Pacific oceans, here within less than fifty miles of each other.

The marine algæ proving unexpectedly scarce, especially on the Pacific side of the isthmus, there was considerable opportunity for taking photographs of general botanical interest and the lantern-slides shown illustrated chiefly some of the more striking features of the land flora of the Canal Zone, such as the numerous native palms, the vegetation of the extensive fresh-water swamps between Colon and Gatun, the swampy forests bordering the Chagres River, and the flora of the rocky islands of Panama Bay. A report covering some of these features of the lecture was published in the *Journal of the New York Botanical Garden* for February, 1910.

The speaker justified a somewhat extended discussion of the Panama Canal and its history by the general interest in the subject both here and on the isthmus. Among the photographs shown were several of the Atlantic and Pacific entrances to the canal, the Gatun locks, a flood on the Chagres River, the Culebra Cut, the Ancon Hospital and the Taboga Sanitarium. The success of modern sanitary methods in combating yellow fever and malaria was especially dwelt upon. The speaker alluded also to incidents of interest in the romantic early history of the isthmus and in the building of the Panama Railroad. Photographs of the ruins of Old Panama, located about five miles east of the present city, were also shown.

Sereno Stetson,
Secretary pro tem.

THE AMERICAN CHEMICAL SOCIETY
NEW YORK SECTION

The fifth regular meeting of the session of 1910–11 was held at the Chemists' Club on February 10.

The chairman spoke of the great loss to the society in the death of Professor Kinnicutt and called upon Dr. Clifford Richardson to make a few remarks about his career. Professor Morris Loeb paid a further tribute to Professor Kinnicutt and then, passing from a matter of deep regret to one of rejoicing, spoke of the festivities connected with the opening of the new chemists' building in New York, beginning March 17.

The chairman read a letter of regret from Professor Boltwood, who was unable to be present to read a paper on "Radio-chemistry," announced on the program. He then called upon Professor A. T. Lincoln, of Rensselaer Polytechnic Institute, who presented a résumé of recent work on the subject of solutions under the title "The Hydrate Theory."

The rest of the evening was devoted to a symposium on milk, which comprised the following subjects:

"Determination of Total Solids in Milk," Paul Poetschke, of the Lederle Laboratories.

"Milk Costs," W. E. J. Kirk, medical adviser to the Borden's Condensed Milk Company.

"Raw and Pasteurized Milk and Milk Serums," Edward Gudeman, of Chicago.

C. M. Joyce,
Secretary